Laboratory investigation of the role of energetic electron beams in wave generation in the solar corona and in the heliosphere

Completed Technology Project (2018 - 2021)

Project Introduction

Science Goals and Objectives The most energetic electrons in Solar Energetic Particle (SEP) events can extend to more than several MeV. At the Sun, electron beams at these energies are usually associated with hard x-rays and gyro-synchrotron radiation. These electrons might also excite whistler-mode waves that could contribute to energy loss from the beams, produce turbulence, and locally heat plasma. Although these relativistic electrons have been observed directly by satellites in the interplanetary medium and inferred from remote sensing, it is not known whether they may also be associated with the generation of Type II and Type III radio bursts, in addition to the usually invoked ~keV beams. Understanding the roles of relativistic electrons (from ~100 keV to ~1 MeV) in the generation of radio waves and other modes, the efficiency of the relevant processes and their contribution to the energy balance in solar flares and other active solar events is critical to understanding partitioning of energy in solar events, as well as propagation of SEP electrons. Motivated in part by the opportunities and needs of the upcoming Solar Probe Plus mission, the proposed research aims to address the following questions: 1. What wave modes (Langmuir, whistler, etc.) are generated by relativistic electron beams in plasmas with characteristics similar to the solar corona and near-Sun solar wind? Are the properties of these waves consistent with observations? 2. Under what conditions can relativistic electron beams generate radio waves, either directly or by exciting plasma oscillations first, that could explain some features of solar radio emission, such as Type II and Type III bursts? 3. What signatures of the above processes can be tested by observations from Solar Probe Plus, other in-situ and remote sensing instruments to determine the mechanism of wave generation by electron beams near in the sun? Methodology We propose to investigate these important questions utilizing laboratory experiments at the Large Plasma Device (LAPD) at UCLA, simulations, and comparison to satellite data. The LAPD has a highly reproducible 21 m long and 60 cm diameter quiescent plasma column produced by a large area cathode-anode source. The values of various dimensionless parameters (e.g. plasma beta or the ratio between plasma and electron cyclotron frequencies) can span a range of values comparable to the near-Sun solar wind and corona. The LAPD is equipped with an extensive set of diagnostics and an automated data acquisition system. The experiments will utilize a unique variable-energy (from 100 keV to 1 MeV) electron beam recently developed at LANL. Experimental campaign will be supported by an extensive theory and simulation effort necessary both to guide and/or interpret the experimental data and extrapolate the results to other parameter regimes. Relevance The proposed research is will provide new understanding of physical processes directly relevant to goals of NASA's Heliophysics program to "explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system , advance our understanding of the connections that link the Sun, the Earth, …, and develop the knowledge and capability to detect and predict extreme conditions in space …" The results are also directly relevant to the objectives

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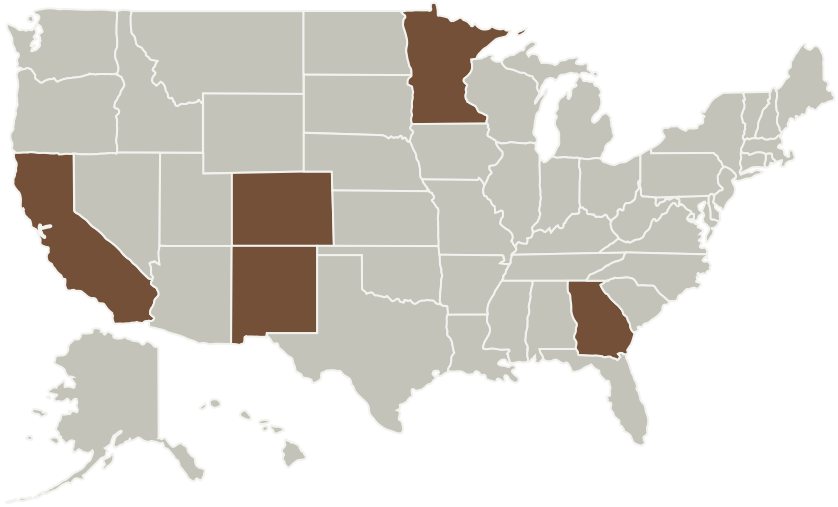
described in the Heliospheric Decadal Survey, specifically Goal 3 ,"Determine the interaction of the Sun with the solar system…" and Goal 4, "Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe." The results of the investigation will have direct impact on the Solar Probe Plus mission by providing both deeper understanding of the physical processes associated with SEP, beam-driven plasma waves and turbulence, and by developing a relevant set of observational signatures.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Space Science Institute	Lead Organization	Industry	Boulder, Colorado
University of Minnesota-Twin Cities	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Minneapolis, Minnesota

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Space Science Institute

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Vadim S Roytershteyn

Co-Investigators:

Courtney L Stanton
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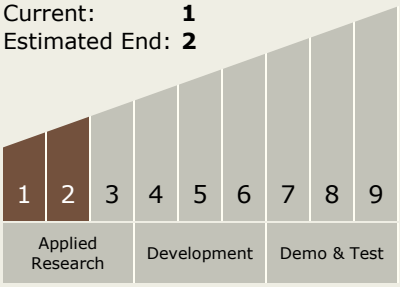
Primary U.S. Work Locations	
California	Colorado
Georgia	Minnesota
New Mexico	

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

The Sun